

REMARKS

Claims 1-7 and 9-14 were rejected under 35 U.S.C. §103(a) as being unpatentable over US Pat. 6,179,780 (Hossack et al.) in view of US Pat. Pub. No. 2001/0039381 (Burns et al.) Claim 1 describes an ultrasonic imaging system comprising a probe including a single crystal transducer array exhibiting a transducer band; a transmit beamformer coupled to elements of the transducer array and controlled to cause the probe to transmit two or more beams during the same transmit interval in different beam directions, wherein each beam occupies a substantially different bandwidths of the transducer band; a receive beamformer coupled to process two or more receive beams in response to the transmitted beams during the same receive interval, the receive beams exhibiting steering directions corresponding to those of the transmitted beams; a filter coupled to the beamformer which acts to filter the receive beams; a signal processor coupled to the filter; an image processor coupled to the signal processor; and a display coupled to the image processor which displays an image formed from components of the receive beams. An ultrasound system of the present invention provides 3D imaging at a high frame rate of display by transmitting and receiving multiple beams during the same transmit/receive interval. To distinguish between the beams during receive, each beam occupies a substantially different bandwidth of the passband of a single crystal transducer array. The single crystal array enables the transmission and reception of frequency-separated broad band beams, the bandwidth of which provide the 3D image with good axial resolution.

Hossack et al. are also trying to transmit and receive multiple beams at the same time and realize that it is necessary to reduce cross talk between the several beams so that they can be readily distinguished on receive. One of the techniques that Hossack et al. suggest is based on frequency diversity as shown in their Fig. 10. But Hossack et al. are using a transducer array which is "substantially conventional." They tell the reader in col. 2, lines 23-25 that "any suitable 2-D transducer array 12 can be used." Such a conventional array is described on page 3, lines 3-21 of the present specification, where the characteristics of a conventional piezoelectric transducer are contrasted with those of a single crystal transducer of the present invention. Since Hossack et al. are using a conventional transducer, they cannot transmit beams with substantially different bandwidths as called for by Claim 1 without using narrow bands that would unacceptably reduce axial resolution of the ultrasound image. If they would use desirably broad bandwidths for the two beams to provide the axial resolution they want, the bands would have significantly overlapping

passbands and have unacceptable cross talk. Faced with these conflicting tradeoffs, they do the best they can, which is to provide only different transmit center frequencies. Each beam is modulated with a different center frequency, and the two beams are distinguished on receive by detecting the different center frequencies. See col. 4 at lines 56-64. Hossack et al. do not say how much band overlap there is between their two beams. But by distinguishing the two on the basis of center frequency they have implemented a bandwidth reduction which will manifest itself as degradation of axial resolution. Hossack et al. also do not give any statistics on their axial resolution. But it is clear that Hossack et al. never consider a single crystal transducer as called for by the present claimed invention, nor do they suggest using substantially different bandwidths for their transmit beams as called for by Claim 1. Instead, they modulate their beams with different transmit center frequencies which are distinguished by filtering on receive.

Burns et al. is cited for its mention of a single crystal transducer in col. [0016]. But Burns et al., like Hossack et al., have no preference for any specific type of transducer, saying in that paragraph that "the transducer can also be any pulsed ultrasound transducer." For Burns et al., a single crystal transducer would afford no special performance. That is because Burns et al. are doing pulse inversion Doppler imaging. See paragraph [0031]. As is well known, Doppler systems are preferably narrow band so that the Doppler shift can be consistently detected at the same frequency. See paragraph [0030], where Burns et al. state their preference for sharp filter cutoffs. Consequently Burns et al. do not suggest using single crystal transducers in a broad band system such as that of Hossack et al. Hossack et al. say that their approaches are applicable to both broad band (B mode) and Doppler systems alike. See col. 5, lines 5-9 of Hossack et al. Neither patent recognizes the problem of axial resolution degradation due to the use of narrow pass bands (which the Examiner notes is well known on page 3 of the Office action). Consequently Hossack et al. does not suggest using a single crystal transducer for their dual beam embodiments and Burns et al. do not, either. Thus it is respectfully submitted that the approach of the present claimed invention is not suggested in these two patents, nor are the benefits to be realized in doing so. Accordingly it is respectfully submitted that Claim 1 and its dependent Claims 2-14 are patentable over Hossack et al. and Burns et al.

Claim 8 was rejected under 35 U.S.C. §103(a) as being unpatentable over Hossack et al. and Burns et al. and further in view of US Pat. 6,558,328 (Chiao et al.) Chiao et al. was cited for their teaching of mismatched filters. Chiao et al. are concerned with using encoded transmit pulses for contrast imaging. For that, they suggest a transducer array with

no special properties. See col. 4 at lines 53-57. Chiao et al. make no mention of single crystal transducers. Hence for Chiao et al., as is the case for Hossack et al. and Burns et al., no special transducer including a single crystal transducer is urged for any particular application. Chiao et al. are also not concerned with multiple beam transmission. And Chiao et al., like the other two patents, does not suggest using substantially different bandwidths for simultaneous transmit beams as called for by Claim 1. For these reasons it is respectfully submitted that the combination of Hossack et al., Burns et al., and Chiao et al. cannot render Claim 1 and its dependent claims including Claim 8 unpatentable.

The prior art made of record and not relied upon has been reviewed and is not believed to affect the patentability of the claims discussed above. To complete the citations, an information disclosure statement is enclosed which references US Pat. 6,425,869 which is described on page 7, line 25 of the present application. While the 1996 paper by Lopath et al. on single crystal transducers has already been made of record, the '869 patent, while being cumulative, is mentioned for its discussion of manufacturing methods for a single crystal transducer.

In view of the above, it is respectfully submitted that Claims 1-14 are patentable over the combination of Hossack et al., Burns et al., and Chiao et al. Accordingly it is respectfully requested that the rejection of Claims 1-14 under 35 U.S.C. §103(a) be withdrawn.

In light of the foregoing remarks, it is respectfully submitted that this application is now in condition for allowance. Favorable reconsideration is respectfully requested.

Respectfully submitted,

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